THEMIS

Education and Public Outreach Plan

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Executive Summary

The THEMIS (Time History of Events and Macroscale Interactions during Substorms) Mission will determine the onset time and location of magnetic substorms of Earth's space environment, a prerequisite to understand space weather, with five satellites and an array of ground stations near to the Arctic Circle in North America and the subauroral states spread longitudinally to cover the country.

As part of the formal education of the E/PO program for the THEMIS mission, thirteen new ground magnetometer stations will be established at secondary schools, tribal and community colleges in ten states. In addition three most northern Alaska sites also have all-sky cameras to observe the auroras in white light. The Space Grant Consortia of the eight states will work with the Mission and the state schools to identify the location for the magnetometer stations. The E/PO team will coordinate local educational and outreach effects of the new facility, its data, and the THEMIS mission, extending the impact of the magnetometer station beyond the single school at which it is located. This unique component of the project provides students and teachers with project-based activities that support inquiry and access to real scientific data, an important focus of the National Science Education Standards. These activities are theme-based, engaging students in projects that foster scientific inquiry and model the practices of science research. THEMIS utilizes this approach to introduce to K-12 students themes of fundamental importance, such as space weather and its effects on the habitability of the near-Earth environment, on satellite communications, and on electrical power distribution on Earth.

To maximize our impact on the Native American community through the selection of magnetometer installed schools we reach out to large populations of Native American youth. Through the South Dakota and Montana NASA Space Grant Consortium which are involved in training teachers and students on space science, we will create lesson plans and experiments used in their classrooms. We expand the level of services to other Native American students and tribal schools by offering teacher workshops in southeastern Idaho and Utah.

The project will also contribute its science discoveries to update the "Northern Lights" planetarium show, and distribute it through the small planetarium consortium.

The E/PO will engage diverse educational and general public communities, develop products and programs to be disseminated through existing national education networks, and make a concerted effort to reach underserved populations through professional development workshops and Space Grant Consortia dissemination efforts.

The THEMIS E/PO partnerships, methods, activities, and visibility is monitored and evaluated by Cornerstone Evaluation Associates, an established independent evaluation group with experience in evaluating the development of science learning resources and the use of technology in science education.

A. Introduction

A1. Goals and Overview

The THEMIS mission will determine the onset time and location of magnetic substorms in Earth's space environment, a prerequisite to understanding space weather. THEMIS will also determine what mechanisms cause the explosive nature of auroral substorm onset. The THEMIS team, recognizing our country's need for improved mathematics, science, and technology education (TIMSS 2000 www.timss.org), proposes a nation-wide partnership with science centers, K-14 educators, professional science organizations, and mission scientists to implement a comprehensive education and public outreach program. Our main goals for such a program are to:

- Share the excitement of real-time measurements with science teachers and students using magnetometers that are placed in their own schools and networked with other schools across the country;
- Develop lesson plans that adhere to appropriate grade-levels and National Science Education Standards (NSES) and create THEMIS magnetometer instruction manuals appropriate for in-class use;
- Update the Northern Lights Planetarium Show with new science discoveries from the THEMIS mission;
- Share THEMIS discoveries with teachers, students, and the general public through well developed E/PO web pages;
- Share THEMIS science in the context of other NASA missions such as IMAGE, FAST, STEREO, and RHESSI;
- Motivate scientists involvement in E/PO;
- Use existing infrastructure in order to leverage THEMIS E/PO activities and to avoid duplication of effort;
- Partner with Tribal Colleges and the Society for Advancement of Chicanos and Native Americans in Science (SACNAS) to reach minority and underserved groups; and
- Provide teachers across the country professional development opportunities.

We plan to meet these goals using four main projects:

1. The Geomagnetic Event Observation Network by Students (GEONS) in which 10 magnetometers are placed in 10 schools across the country to receive data from the mission and to teach about Earth's magnetic field and its changes that are related to auroral substorm activity;
2. Launch of a new Lawrence Hall of Science (LHS) Great Explorations in Math and Science (GEMS) site in Nevada;
3. Update of the LHS Northern Lights Planetarium Show, using THEMIS discoveries;
4. Development and maintenance of a THEMIS E/PO Website
5. Provide professional development to teachers with a focus on the Tribal College

and SACNAS communities.

In order to ensure that our goals are being met by our efforts, all activities will be assessed and evaluated by Cornerstone Evaluation Associates. Our products will be disseminated through a wide range of national networks.

The THEMIS E/PO plan benefits from SEGway's successful E/PO models on HESSI, STEREO/IMPACT, and CHIPS. This plan embodies proven E/PO practices of diversification and efficient strategies in reaching underserved populations, in direct confluence with the guidelines of NASA OSS "*Partners in Education* and *Implementation Strategy*". The project devotes about 1.5-% of its budget (excluding launch) to E/PO and E/PO-related activities over 5 years. This support allows a mature E/PO team to reach its goals through its planned activities as outlined above.

A2. The THEMIS E/PO Team

The THEMIS E/PO team builds upon an existing University of California Berkeley network of national partners. Dr. Craig, Director of the SEGway group at the Center for Science Education (CSE) at the Space Sciences Laboratory (SSL) will lead the E/PO effort. Dr. Peticolas, a space scientist and member of the SEGway group (and Lead of the FAST E/PO), will work with Dr. Craig and the THEMIS E/PO partners. The THEMIS E/PO partner institutions, headquarters location, and roles in the E/PO activities are shown in

Partner	**Headquarters**	**Role, Products and Programs**
SEGway@SSL	Berkeley, CA	Leadership and coordination. Development of SEGway Web-module. Leverage of SECEF resources for use in K-4 (auroras) and 6-12. *Formal Education*.
Astronomy Café - GEONS	Kensington, MD	Development of GEONS resources and teacher training. *Formal Education*
OSS Support Network, Student Observation Network	Washington, D.C., Greenbelt, MD	Dissemination through National Conferences and other existing networks. *Informal Education and Public Outreach*
IMAGE and FAST E/POs	Greenbelt, MD Berkeley, CA	Dissemination. Identification of Professional Development Workshops for educators. Using existing resources. *Formal and Informal Education and Public Outreach.*
Lawrence Hall of Science, UCB &Carson City School district	Berkeley, CA	GEMS Distr. & Training Center PD Program in the Carson City School District. *Formal Education*
LHS – SEGway -UCB	Berkeley, CA	" Northern Lights Planetarium" show . Updated with THEMIS discoveries. *Informal Education*
SACNAS, SECEF and LHS PD partners	El Paso, TX	Teacher workshops with Chicano and Native American Teachers at Tribal Colleges. *Formal Education*
Space Grant Consortia (8 States)	Bozeman, MT (coordinator)	Selection of School Sites- Dissemination Workshops. *Formal Education*
Carson City School District, NV and Walter Peyton School in IL	Chicago, IL; Carson City, NV	Committed schools, teachers and school district administration for the Magnetometer sites for NV and IL: New GEMS site venue. *Formal Education*
Cornerstone Evaluation	Pittsburgh, PA	Formative and Summative Evaluation.

Table A-1.

The THEMIS E/PO program builds on the infrastructure of several national leaders in education and public outreach. Dr. Sten Odenwald, creator of the Astronomy Café and IMAGE E/PO director joins the partnership with his well-established MagNet program based at the Walter Peyton School in Chicago, IL. Alan Gould, Holt Planetarium Director at LHS, will update the development and production of the "Northern Lights" Planetarium Show with THEMIS updates. Caroline Willard, GEMS network director at LHS, will organize the distribution and training of the GEMS Teacher Professional Development workshop in Nevada. Dr.'s Hiscock and Larson of the Montana Space Grant Consortium will coordinate with other Space Grant Consortia and teachers in order to select the school locations of the magnetometers. In particular, Dr. Larson, will contact the Directors of the Space Grant Consortia of AK, MI, ND, OR, PA, SD, and WI and organize the school competition. Gail Bushey, a teacher of science and mathematics and a GEMS Associate, Mike Watty, District Assistant Superintendent of Carson City School District, NV will work with us to find a school in Nevada for a magnetometer site and a teacher to work with the magnetometer data. Dr. Lopez will facilitate the inclusion of THEMIS teacher workshops into the SACNAS K-14 workshop program. Allyson Walker of Cornerstone Evaluation Associates will work with her staff and associates, together with the THEMIS E/PO team, to perform the formative and summative assessments and evaluations of the various aspects of the THEMIS E/PO program. Please see the letters of support in the submitted E/PO proposal.

Formal Education Informal Education Public Outreach Cross Cutting

Table A- 1: *The partners involved in the THEMIS E/PO program*

A3. Changes and Updates to the E/PO Plan in Phase B

Besides elaborating on the THEMIS E/PO program and its timeline, this implementation plan has several updates and changes from the original E/PO proposal. One update is that Dr. Peticolas has been hired as an Education and Public Outreach Specialists for the SEGway program at CSE at UCB. She now works with Dr. Craig and the SEGway team on several NASA Mission E/PO activities, including THEMIS activities and is expected to take a major role by the time THEMIS launches.

A recent development in Phase B of the Mission Ground-Based Observatory (GBO) program is to include teacher involvement in the weekly operational needs of the Ground-Based Observatories in Alaska which was not in the original E/PO proposal. Dr. Peticolas has been working with Dr. Mende, the lead on the GBOs, and Neal Brown, Director of the Alaska Space Grant Consortium, to find interested teachers. As part of the teacher's GBO contract, we plan to include them in the teacher workshops for the GEONs teachers. We will include them in classroom lessons that are created and work

with them to bring the THEMIS science into the classroom, especially involving the GBO instrument contributions. The related teachers' expenses will be covered by the GBO group.

Also during Phase B planning, the magnetometer delivery and installation time-line has changed. Five magnetometers will now be delivered and installed in August, 2004 and tested in the subsequent months with the teachers. The remaining five magnetometers will be installed in August, 2005 and tested in September 2005 with the full network in place.

B. Formal (K-14) Education Activities

B1. Geomagnetic Event Observation Network by Students (GEONS)

a. An inquiry-based approach to THEMIS science

The nature of the THEMIS science investigation, in particular the correlation of ground-based measurements of auroral activity with spacecraft-based measurements of changes in the magnetosphere, holds tremendous potential for inquiry-based instruction of pre-college students and teachers. In recognition of this, THEMIS E/PO establishes ten ground-based magnetometer stations each located in the proximity of a rural school in traditionally under-served, under-represented communities. A teacher at each of these schools is responsible for their magnetometer data and system as well as using the data with their students through lesson plans developed by SEGway and the Astronomy Café. The network of the 10 teachers, students, and magnetometers together with other students who participate using the Web is called the Geomagnetic Event Observation Network by Students (GEONS).

This unique component of the project provides students and teachers with project-based activities that support inquiry and promote access to real scientific data collected in their neighborhood. This is one of the key targets of National Science Education Standards (NSES) that is not routinely supported by traditional science curricular materials. The National Research Council called for instruction that is theme-based, engaging students in projects that foster scientific inquiry and model the practices of science research. THEMIS utilizes precisely the above approach to introduce to K-14 students to themes of fundamental importance, such as space weather and its effects on the habitability of the near-Earth environment, on satellite communications, and on electrical power distribution on Earth.

There are several steps and partners involved in making GEONS successful. Dr.'s Hiscock and Larson at the Montana Space Grant Consortium coordinates the other Space

Grant Consortiums in finding eight of the ten schools for the magnetometer sites. Two of the ten schools have already been selected because of their location, enthusiasm, and/or experience. All ten teachers need to be selected and/or verified as magnetometer custodians. THEMIS E/PO team and the Astronomy Café with support from the UCLA magnetometer team are responsible for creating appropriate teacher lessons, magnetometer user manuals, linked web pages, and for providing teacher workshops for the teachers involved in GEONS. If teachers are selected as custodians of the GBOs in Alaska, they also will be included in some of these workshops and in the lesson plans. The teachers and magnetometer sites involved in the MagNet program of Dr. Sten Odenwald of the IMAGE E/PO lead expands our GEONS network to at least twice the size using/adding his MagNet Network.

b. Site Selection and Space Grant Partners

In an effort to best utilize existing infrastructure and reach out to a larger sector of the K-14 community and the public, the THEMIS E/PO has partnered with the following Space Grant Consortia, coordinated by and including Montana State: Alaska, Oregon, North Dakota, South Dakota, Wisconsin, Michigan, and Pennsylvania for selecting the schools that will become the host-sites of the ground magnetometers. Figure 1 shows a map of the U.S. with these states colored in purple.

Figure 1: *The key states that are directly involved in the THEMIS E/PO Plan. States colored in purple are those that will house the GEONS magnetometers. These sites will be selected through the Space Grant Consortia. States in red will also be part of the formal education aspect of the E/PO plan with Nevada and Illinois housing GEONS magnetometers. SACNAS teacher professional development will occur in the states colored in green*

For the GEONS plan, this consortium of Space Grant partners will conduct a statewide competition in each state. The selection criteria are (i) commitment of the school/teacher

and availability of local infrastructure, (ii) demonstrable advancements to the education process at the particular school with particular consideration towards reaching underserved students, (iii) the potential for reaching a large community of students and teachers, and (iv) the site's potential for science discoveries, based on its geographic location within the state, that may result in stronger interactions with the THEMIS research team. The competition will take place between January and April 2004 and sites will be selected by June, 2004. This will ensure that the sites are known by the time the first five magnetometers and Alaska GBOs are installed in August 2004.

These Space Grant Consortium have strong ties with under-served, under-represented communities at rural areas. Tribal Colleges, which maintain a strong local community presence, are affiliates of their state Space Grant program and are also excellent target sites for THEMIS E/PO data collection stations. These networks serve as effective venues for teacher professional development workshops focusing on data-centered classroom activities.

c. Educational Products and Teacher Professional Development

SEGway is a mature program with more than seven years' experience and with an established national consortium of science museum partners. SEGway has established a robust process for producing effective, inquiry-based classroom resources tied to the NSES. The Astronomy Café has had more than seven years' experience explaining astronomy to the general public, has years of experience with education magnetometer networks, and has been involved with several excellent K-14 magnetism lessons.

Dr.'s Odenwald, Craig, and Peticolas shall develop, in consultation with THEMIS PI, THEMIS scientists, a teacher intern, and existing technical magnetometer user manuals: (1) a ground magnetometer user manual appropriate for a school setting, (2) nationally-tested inquiry-based lesson plans, and (3) learning materials on how to utilize the magnetometer data to enhance classroom instruction in space science concepts. The lesson plans include topics such as: Forces and Motion, Magnetic Induction, The Geomagnetic Field, Solar Storms and Space Weather and data analysis as appropriate. The specific formal education modules and products are guided by analysis of identified gaps in the 6-14 grade curriculum and alignment with the NSES. These lessons and manuals will begin to be developed in January of 2004. They will be tested starting in the late spring of 2004. Some flexibility will be built-in to the testing so that a suitably motivated teacher could use the data as is in a set of simple lessons. These materials are both Web and paper-based. Included in these lessons are several magnetism lessons that have been developed and tested by NASA missions, including the MagNet magnetometer lessons and the recent magnetism lesson guide developed by the STEREO/IMPACT team (Peticolas, Craig, and Mendez).

In 2005-2006, the SEGway THEMIS E/PO team taps existing K-4 education resources at Center for Science Education at UCB, namely the "Eye on the Sky" program as well as other SECEF resources. SEGway also develops new aurora-related activities within age-appropriate language arts and art classes. These modules are classroom tested in paper form and will be placed on-line at internet-equipped GEONS schools in the ten states. The modules will be disseminated at the NCTM and NSTA and SACNAS conferences. The THEMIS E/PO K-14 module development leverages CSE resources and avoids duplication of products by coordinating with the existing IMAGE, FAST, STEREO/IMPACT, SEGway, and selected SECEF EP/O resources.

Throughout the THEMIS E/PO effort, the Astronomy Café is responsible for coordinating the GEONS program with the MagNet Program, a network of student-built soda-bottle magnetometer stations developed as part of the IMAGE E/PO headquartered at the Walter Payton College Preparatory School in Chicago, IL. Because of his experience with the MagNet Program, we expect that Mr. Sam Dyson at Walter Payton College Preparatory School will be the head teacher in the GEONS network. Starting in the Spring of 2004, Web pages to link the schools data and activities are further developed using the already established MagNet Web pages: http://www.payton.cps.k12.il.us/magnet/. By the Summer of 2006 the development and testing of the paper-based and on-line educational materials will be completed.

As part of the coordination between the GEONS and MagNet programs, the Astronomy Café will organize and hold the teachers' professional development magnetism workshop with participants from both networks in the Summer of 2004. Every year after that, the Astronomy Café and the THEMIS E/PO team work together to hold workshops with the GEONS teachers providing stipends to attend the workshops in order that the teachers continue their professional development related to GEONS and the THEMIS science mission. These workshops provide content, training, and materials for use in existing professional development teacher workshops at our partnering informal education institutions and school districts. Both pre service and in service teachers are familiarized with the best science of THEMIS science topics. All workshops are inquiry-based in both practice and theory and include strong emphasis on both scientific content and effective pedagogical approaches. The workshops in 2007 and 2008 will be held at teachers' national conferences in order to include more teachers in the THEMIS E/PO effort and the THEMIS science. In each of these workshops the educational materials developed will be taught.

B2. Teacher professional development

THEMIS E/PO provides teacher professional development to teachers nationwide as well as those who are part of GEONS. These workshops will be similar in ideal and scope as those mentioned in the GEONS section, but will be held at national conferences such as the NSTA and at CSE after LHS GEMS workshops being held at UCB. We are also

involved in SACNAS and workshops are given at their conferences, as discussed below in Section B4. In this way we reach more teachers than just the ten involved in the GEONS project and possibly the four involved in the Alaska GBO sites.

B3. A New GEMS Site

The THEMIS E/PO team together with the Lawrence Hall of Science (LHS) will launch a new GEMS Network site at the Carson City School District in Carson City, Nevada with a two day Teacher Professional Development workshop. GEMS, the Great Explorations in Math and Science Teacher's Guide series, is a proven resource for excellence in inquiry-based mathematics and science. Developed at UC Berkeley's LHS, GEMS guides are used nationwide from preschool through eighth grade. To support the growing number of teachers using GEMS materials, LHS GEMS maintains an international network of over 55 sites offering professional development and other services for teachers. The sites and centers, sites that offer more resources, are shown in Figure 2 on the U.S.A. map as diamonds and stars respectively.

The proposed Carson City GEMS Network Site serves teachers in northern Nevada. Many of these teachers are in very remote and under served school districts. Carson City was selected as a GEMS site because it satisfies the conditions for being a prime candidate for E/PO magnetometer installation and the because of its strong ties with the GEMS effort. Gail Bushey, a committed and active Associate of the GEMS Program takes the lead at the new site, with the strong support of District Assistant Superintendent Mike Watty. The Nevada State Science Coordinator and the Director of the new Planetarium at nearby Western Nevada Community College also lend their support.

Carolyn Willard of LHS will lead the launching of the GEMS site in the Summer of 2005 with a 2-day leadership workshop, emphasizing space science, earth science, and physical science. Carolyn Willard, Gail Bushey, and Dr. Craig are organizing the long-term science

professional development provided to the teachers in the Carson City region.

Figure 2: *Above are shown the locations of the LHS GEMS sites and centers across the country. The new GEMS site is indicated in Red.*

B3. Under-served minority communities

Figure 3: *Under-served children learning about the Sun-Earth connection in a SEGway activity.*

To maximize our impact on the Native American community through the selection of magnetometer installed schools THEMIS shall reach out to economically disadvantaged school districts with large populations of Native American youth. Through the South Dakota and Montana Space Grant Consortia (already supported by NASA to train teachers and students in space science) the GEONS project creates lesson plans and experiments used in classrooms. Next, the E/PO team expands its services to other Native American students and tribal schools by offering teacher workshops in southeastern Idaho and Utah. To achieve maximum effectiveness with Native American audiences, THEMIS includes other members of the school administration, parents, and tribal elders. Due to state and geographic preferences it is quite likely that at least 3 GEONS schools will be Tribal Colleges. We are also collaborating with the Society for the Advancement of Chicanos and Native Americans in Science (SACNAS) and have the support of one of the directors, Dr. Ramon Lopez, to work with THEMIS E/PO to facilitate the inclusion of THEMIS teacher workshops into the SACNAS K-14 workshop program. The annual meetings of SACNAS provide a professional development program for approximately 140 teachers who serve Hispanic and Native American students. This venue would provide an excellent opportunity to reach SACNAS teachers. Dr. Lopez, an internationally renowned researcher in substorm research, has offered consultations on the design of the workshops to ensure that they are well aligned with the theme of the meeting.

C. Informal Education and Public Outreach Activities

C1. Northern Lights Show Update

The THEMIS E/PO team builds on its experience adapting Sun-Earth Connection discoveries from NASA missions such as FAST and IMAGE to excite the general public. THEMIS, with its science themes centered around the aurora fits nicely in LHS's continuing efforts to evolve and update its existing products in collaboration with CSE@SSL. The *Northern Lights* is a planetarium show, the 13th volume in the series known as Planetarium Activities for Student Success (PASS) produced by LHS. Northern Lights became a product of the Sun-Earth Connection Education Forum and release of

that program in the Spring of 2002 resulted in approximately 100 planetariums receiving show kits for use in school and public shows around the country. The program content has been scrupulously reviewed by SEC scientists.

Beginning in October, 2006, as part of the THEMIS E/PO, Alan Gould of LHS will update the Northern Lights program, replacing images, adding animations, and revising the script to reflect THEMIS mission science discoveries related to auroras. In Summer 2007, Gould will field test the revised show in four planetariums. In the Fall of 2007, updates will be made from the field test and then in Spring of 2008 the updated show will be distributed by LHS to all existing planetarium users (about 100 planetariums). Around this time, Gould will announce the availability of the updated program and distribute it though planetarium conferences and through the world-wide planetarium listserv, dome-L.

C2. Web Page Development

The education and public outreach and the mission Web sites of any NASA Mission are the primary doors to the public. The THEMIS E/PO Web site promises to be an excellent source for the general public to come and learn about THEMIS mission and its science in language appropriate for a general audience. At this Web site, one can learn how to bring THEMIS science and GEONS activities into the classroom, how to understand THEMIS data, and where the THEMIS public activities are taking place. This Web page is currently being developed together with IDEUM to ensure that the Web site is accessible and friendly to the public, teachers, and to the students who visit it, and that the site design is robust enough to withstand the updates over the next five years. We are also making sure that this Web page is accessible to those with disabilities. The launch of the THEMIS E/PO site will occur in November, 2003.

Not only is the Web site designed for the anonymous Web surfer, but there will be a section of the Web pages designed for the GEONS teachers. In these Web pages, teachers can chat with one another, find out about upcoming workshops, and link with the MagNet Web pages.

In addition, we will have a link for NASA education and public outreach specialists and scientists who are interested in our E/PO plan. As each aspect of the E/PO plan proceeds pages are developed to explain the E/PO goals and plans with links to the E/PO projects such as links to the magnetometer lessons developed through the GEONS project, and links to the schools and the data in the GEONS project. As the LHS planetarium show is upgraded, how to access the new shows and an explanation of what has been changed are found on the E/PO Web page.

D. Effectiveness of E/PO Plan

D1. Dissemination and national impact

To disseminate resources nationally and prevent duplication of effort, our E/PO program is coordinated with the Sun-Earth Connection Education Forum, a UC Berkeley/GSFC collaboration, and with the OSS-sponsored Broker/Facilitators nation-wide, as well as networks supported by NASA Education. Examples of the NASA education groups we work with are 1) the Educator Resource Center Network, which is a network of centers around the country that provide educators with in service and pre service training, demonstrations, and access to NASA instructional products; 2) NASA CORE, which provides access to various types of materials that supplement classroom instruction and aid in understanding NASA's scientific research and accomplishments, 3) NASA Glenn Research Center (GRC) Aerospace Education Services Program (AESP), which provides professional development workshops for teachers in the six state area of Illinois, Indiana, Michigan, Minnesota, Ohio and Wisconsin; and 4) Spacelink, which is a Web page where one can find electronic versions of the new NASA educational products. THEMIS mission resources will also be accessible through the OSS Resource Directory, which is compatible and linked to the U.S. Department of Education Eisenhower Clearinghouse and Gateway to Educational Materials resource directories.

THEMIS links to NOAA centers via our NOAA THEMIS co-Investigator Dr. Singer, allow for further dissemination of our education products and outreach activities. THEMIS reports on auroras, solar storms and geomagnetic activity will contribute to Spaceweather.com, a member of the popular Science@NASA family popular Website. National distribution of THEMIS resources takes advantage of the many already existing Web based and physical dissemination networks available through SEGway museum partnerships, at the National Air and Space Museum, Lawrence Hall of Science, Science Museum of Virginia, and the Exploratorium. Working within the SEGway structure thus provides our program with an efficient and high leverage way of serving the needs of both the formal and informal education communities. E/PO staff also periodically publishes articles in the San Francisco Mercury News; the Universe in the Classroom (ASP); Insight magazine (NASA); Science Teacher and National Science Teachers Association newspapers; Working Group on Astronomy Education Newsletter (AAS) and also in the on-line refereed journal, Astronomy Education Review, AER.

D2. Evaluation of E/PO Effectiveness and Impact

The THEMIS E/PO partnerships, methods, activities, and visibility is monitored and evaluated by Cornerstone Evaluation Associates (CEA), an established independent evaluation group with experience in evaluating the development of science learning resources and the use of technology in science education. CEA assesses the effectiveness of the E/PO effort, evaluating: multiplier effect, scope of dissemination, and effectiveness of tapping high-leverage opportunities made available through the partnership with LHS, Space Grant Consortium, and National Teacher Professional Development workshops. CEA collects formative information from partners about communication, cooperation, goals, and the use of resources, in order to make any necessary mid-course corrections. CEA works alongside with the LHS and its internal evaluation groups on the effectiveness of the establishment of the new GEMS site and the Northern Lights Planetarium update. The evaluation plan includes two major thrusts—1) **Formative—**

the documentation of partners' views of the strengths, weaknesses and necessary improvements of their programmatic contributions, and 2) **Summative—**assistance to partners in gathering outcomes data to measure program impact. In addition to CEA's evaluation and assessments, all E/PO products are submitted to the content evaluation process of NASA OSS.

FY05-FY08—Formative Evaluation Activities

Cornerstone will provide an external evaluation perspective by conducting yearly (FY05-FY08) partner surveys to document the development, dissemination and perceived outcomes/impact of each partners' program activities. These surveys will focus on the current year's accomplishments and disappointments; strengths, weaknesses and necessary improvements of programs/products; lessons learned—what worked well, what caused problems; success of dissemination efforts in reaching targeted minorities, etc.

The survey strategies will include both e-mailed questionnaires and in-depth telephone interviews. Data will be predominately qualitative with some quantitative rating-scale items. Cornerstone will conduct surveys and report findings on a yearly basis with the final year's report being a comprehensive, compilation of the entire documentation effort. Data will be presented for each partner individually.

The information that emerges from documenting product/program development, implementation, and dissemination are used for two purpose: to provide formative/process feedback for improving the educational products and programs, and to serve as a guide or model for replicating/disseminating partners' programs/products.

FY05-FY08—Summative Evaluation Activities

For the most part, the E/PO partners have in place their own internal evaluation efforts—to measure the outcomes of their contributions. Cornerstone serves as a consultant to partners offering methodological and analysis expertise and assistance when required.

More specifically, Cornerstone works side-by-side with key personnel from each of the partnering sites to determine the scope of each site's evaluation needs—what they already have in place, and what assistance they require. Cornerstone serves as a consultant to each site in developing and reviewing data collection instruments and in analyzing and interpreting the qualitative and quantitative data that are gathered.

Summative data will be gathered and reported to Cornerstone by individual partners according to a time line that is appropriate to the development of their programs/products. See Table 2 for this timeline. Cornerstone will then be responsible for reporting all 'outcomes' findings from all partners as these data are submitted. Finally, Cornerstone will assemble a comprehensive, end-of-project report of the outcomes data generated by each site.

PARTNER/ACTIVITY	FY05	FY06	FY07	FY08
GEONS teachers	X			

SEGway@SSL—6-9 and K-4 resources		x	x	
GEONS—9-14 resources	x	x	x	
LHS—New GEMS Center	x	x		
LHS – Northern Lights Planetarium Show				x
SACNAS/other professional development workshops		x	x	x

Table D- 1: *The evaluation time-line for Cornerstone Evaluation Associates*

Cornerstone will ascertain their evaluation needs in order to determine where Cornerstone assistance can best be used. This process will involve

- clarifying goals/objectives
- determining extent to which goals reflect National Science Education Standards
- establishing an understanding of current internal data collection activities
- delineating what 'new data' need to be gathered
- identifying best methods/strategies for gathering data
- identifying analyses techniques that will be used
- developing timelines for providing Cornerstone with data

Where necessary, Cornerstone will provide collaborative assistance in instrument development/selection and data analysis/interpretation in order to measure program outcomes/impact. It is anticipated that partners will require differing degrees of assistance.

GEONS selected teachers—Cornerstone's expertise will be used for developing questionnaires or interview protocols to assess teachers' perceptions of workshops (Level1) and teachers' experiences with implementation/classroom application (Level3).

SEGway and GEONS resources—Cornerstone will be involved in developing on-line teacher survey questionnaire for tapping teachers' experiences with the site and using the lessons as well as their views of their students' reactions to the lessons. Additionally, these partners may request assistance with data interpretation/analysis.

LHS New GEMS Center and Planetarium—it is anticipated that LHS has its own, comprehensive evaluation efforts already built into their programs.

SACNAS—this partner has its own internal evaluators so we expect to work collaboratively with them as well as supplement their teacher workshop evaluations with our own.

Partners will be responsible for collecting their own outcomes data. Cornerstone will assist any partner with instrument development and data analysis when help is required.

FY08—Final Reporting Activities

The final comprehensive report will include the 4-year history of 'process' data—based on yearly surveys documenting the development, implementation and dissemination of

programs and products. In addition, this report will include final 'outcomes' data revealing the impact/effectiveness of each partners' program.

D3. PI and Science Team Involvement

The THEMIS PI, Dr. Angelopoulos, and the THEMIS scientific and technical teams at UCB, UCLA and NASA-funded co-I institutions are committed to provide input on the scientific accuracy of the materials developed, to collaborate and communicate with E/PO partners, and to participate in the science center/museum presentations. As PI, Dr. Angelopoulos oversees the E/PO Program.

The E/PO Lead, Dr. Nahide Craig, provides direction to the THEMIS E/PO effort and ensures the coordination of the proposed activities with the help of key E/PO personnel at the partner institutions. Dr. Craig is uniquely qualified to lead the E/PO effort, having coordinated numerous successful UCB mission E/PO components, including the RHESSI, STEREO/ IMPACT, CHIPS, and FAST Missions. To support the E/PO efforts at Berkeley, she supervises a team composed of an E/PO scientist/specialist, Dr. Peticolas, summer teacher interns, and a grant administrator. Dr. Craig is responsible for all written E/PO reports, including the contributions for mission reviews, and reports directly to Dr. Angelopoulos.

THEMIS team members Dr.'s Delory, Bester, Bonnell, Singer, and Ergun, participate in the E/PO functions as guest speakers and contribute THEMIS stories to popular science magazines. The above members have been or are active in UCB's E/PO program in similar roles in the past. For example, Dr. Bester, the Mission Operations Manager, has conducted mission operation center tours and delivered public lectures on SSL activities. Drs. Delory, Peticolas, Craig and PI Angelopoulos, participate in the LHS planetarium show update development, and dissemination. The co-I team at UCLA is personally committed to the E/PO effort led by Dr. Russell, who is also the Director of the UCLA branch of the California Space Grant Consortium and provides technical support on THEMIS E/PO magnetometers.

By building on successful E/PO programs, such as those of FAST, HESSI, CHIPS and STEREO/IMPACT, and by securing strong and meaningful partnerships the experienced THEMIS E/PO team shall lead a sustained, well-evaluated program that supports the involvement of scientists and their research in education for the benefit of broad audiences.

E. E/PO Implementation Plan

E1. *Timeline Detail*

E/PO activity	FY04				FY05				FY06				FY07				FY08			
	2003	2004				2005				2006				2007				2008		
	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep
Set up ongoing communication structure between EPO partners to finalize and update EPO plans																				
THEMIS E/PO Web page development, refinement, and update																				
SPACE GRANT Magnetometer School Site Selection																				
GEONS module development, testing and use in classrooms																				
Magnetometer Delivery, Installation , and Testing																				
GEONS Teachers Workshop																				
SEGway module development																				
Coordinate resource formats with the SECEF, NASA Ed., and other dissemination groups.																				
LHS GEMS Site launch																				
In service workshops SACNAS																				
Disseminate THEMIS Education Web site through national SEGway museum consortium																				
Northern Lights Planetarium Update																				
Release classroom materials and teachers' guide through SEGway program																				
Integrate classroom materials with resource directory																				
Teachers professional development workshops																				
Cornerstone Evaluation Associates + Internal evaluations																				

Formal Education Informal Education Public Outreach Cross Cutting

Table E- 1: *The time-line for the implementation plan of the THEMIS E/PO activities. The colors correspond to Formal Education (Red), Informal Education (Blue), Public Outreach (Yellow), and Cross Cutting, e.g. all three (Grey). See the text for further details about each activity and when different aspects of that activity will take place.*

a. October, 2003 to September, 2004 (FY04)

THEMIS E/PO has already begun by communicating with the THEMIS partners to confirm the detailed schedule of the plans outlined here, working with the GBO THEMIS team, and developing the THEMIS E/PO Web site. Throughout FY04, the THEMIS team will communicate with partners to ensure that plans are going as scheduled. The inclusion of teachers into the GBO program is settled by the end of October, 2003. THEMIS E/PO becomes visible to the public starting in November, 2003 with the launch of the E/PO Web site and in November, 2003, Montana Space Grant Consortium contacts the other Space Grant Consortia in other states to begin the GEONS site selection via a teacher competition

Starting in January, 2004, the Astronomy Café prepares high school level materials to describe magnetometers and space weather using their existing materials. In March, the Astronomy Café works with the E/PO team to use the UCLA magnetometer user manual to write the Magnetometer Users Manual for teachers. Additionally, the appropriate software will be written together with the THEMIS science team so that teachers and students can easily retrieve real-time and earlier data from the network.

The Users Manual is finished by the end of May, 2004 as is the data software for the teachers. At this same time, the schools and teachers for the GEONS sites are chosen and the Astronomy Café, the Space Grant Consortia, and the THEMIS E/PO team work together to contact the participating schools to make them aware of the GEONS plan. At this time, schools are provided with extant literature produced by SECEF missions that describes space weather and explains aurora/magnetic storms. In June 2004, SEGway and the Astronomy Café partner to begin curriculum materials that specifically highlight the possibilities for using this magnetometer network to support classroom activities and concept learning starts.

In late July 2004, the Astronomy Café and the THEMIS E/PO team will organize a GEONS teachers' workshop. This workshop focuses on what magnetometers do, how to analyze the data, and the science of geomagnetic disturbances and auroral substorms. In August, 2004 five magnetometers are delivered and installed in five states by the UCLA team, the selected teachers, and the partnering Space Grant Consortium personnel in the state where the magnetometer is installed. The data software is tested at this time as well, into September, 2004.

b. October, 2004 to September, 2005 (FY05)

In October, 2004, the Astronomy Café and the GEONS head teacher expands the MagNet online data registry to handle student reportage of magnetic disturbances and constructs a student 'Magnetic Disturbance' index. At this time, Cornerstone Evaluation Associates begins to develop the forms to gather evaluation and assessment data regarding

the GEONS Web interface, teacher workshops, classroom materials, and the user manual, as well as to work with the Space Grant Consortia to evaluate the site selection process. Starting in November, 2004 the Astronomy Café, the GEONS head teacher, and the E/PO THEMIS team tests the Web and paper resources in the classroom at GEONS sites. The Web together with a buddy system will be used to train the teachers who do not yet have their magnetometers during this school year. The Space Grant Consortia help with the development of this buddy system at this time. By the end of March, 2005, the testing of GEONS materials in the classroom has finished. Throughout FY05, LHS and the THEMIS E/PO team remain in contact with the new GEMS site at Carson City, NV, sending GEMS guides and NASA materials as needed.

In April, 2005, Cornerstone sends out evaluations of the GEONS classroom experience. At this time, LHS assesses the new GEMS site success and evaluate its impact on teachers. From April to June, 2005, SEGway develops K-4 materials with the help of the SECEF group at UCB. In May, 2005, the THEMIS E/PO team coordinates resource formats with the SECEF, NASA Education, and other dissemination groups. In late June, 2005, the Lawrence Hall of science launches the GEMS site in Nevada, including a GEMS professional development workshop for teachers.

In July, 2005, the Astronomy Café and the THEMIS E/PO team hold a second annual GEONS workshop to further instruct the teachers about what the magnetometer is doing, how the network operates and its value, how the data can be used in the classroom, and the lessons learned from the previous school year's tests. Cornerstone provides evaluation forms for this workshop. In August, 2005 the remaining five magnetometers are delivered and installed in five states by the UCLA team, the selected teachers, and the partnering Space Grant Consortium personnel in the state where the magnetometer is installed.

c. October, 2005 to September, 2006 (FY06)

In October, 2005, SACNAS is contacted in order to begin the planning of the SACNAS in service teachers. By this time, some of the GEONS magnetometers have been operating for a year or more. This will be the first year that teachers are prepared to use the data in their classrooms to investigate magnetism and magnetic fields between October 2005 and May 2006. During this time, a set of classroom activities and experiments will be beta-tested for the magnetometer.

SEGway module development will continue through FY06. Cornerstone will continue to assess the GEONS and SEGway resources in the spring of 2006. In March, 2006, the THEMIS E/PO team coordinates resource formats and dissemination of the new activities with the SECEF, NASA Education, and other dissemination groups.

The mission EPO Website development, dissemination and updates will be carried out throughout the project, including this year. In January, 2006 the THEMIS Web site will be disseminated through SEGway's national museum consortium.

In August, 2006 we will have the Third Annual GEONS Workshop to allow teachers to compare experiences and re-write classroom activities. A SACNAS in service teacher's professional workshop will also take place during the summer of 2006. Cornerstone will work with the THEMIS E/PO team, Astronomy Café, and SACNAS to evaluate the teacher workshops.

d. October, 2006 to September, 2007 (FY07)

The LHS Northern Lights planetarium script development begins in October, 2006. LHS is funded for development and dissemination efforts of the planetarium show programs. Cornerstone will discuss with Alan Gould at LHS the summative and formative assessment plans for the planetarium show. At this time, we attend the SACNAS National Conference and hold several in service teacher workshops. From October, 2006 to March, 2007, SEGway module development winds down with testing in the classroom and NASA reviews of the products.

In April, 2007, we participate in the NSTA where we conduct teacher workshops and distribute educational materials. In May we release the classroom materials and teachers' guide through the SEGway program and integrate these materials with NASA's resource directory. In June, 2007, we host a teacher workshop at CSE@SSL UC Berkeley. In August, 2007 we have the Fourth Annual GEONS Workshop to discuss how to include the data from the THEMIS mission in the classroom and to share the new THEMIS discoveries. Cornerstone will continue to work with the THEMIS E/PO team, Astronomy Café, and SACNAS to evaluate the teacher workshops.

The Web site is continually updated during FY07, including updates about the new THEMIS discoveries. Communication between the THEMIS E/PO team SEGway museum networks ensures that the Web site continues to be hosted at these museums. Cornerstone helps to evaluate the Web site.

e. October, 2007 to September, 2008 (FY08)

The final year of the THEMIS E/PO plan (FY08) is a time to share the THEMIS discoveries through the Web site, the LHS planetarium show, the GEONS network, and the teacher professional workshops both together with and separate from SACNAS. From January to March in 2008, updates to the GEONS resources will be made if required.

Several teachers' workshops are held in the spring and summer of 2008. In April, 2008, we participate in the NSTA where we conduct more teacher workshops and distribute educational materials. In June, 2007, we host a teacher workshop at CSE@SSL UC Berkeley. In July, 2008 we have the final SACNAS teachers' workshop. The final summative evaluations and report by Cornerstone is completed in the summer 2008 as the E/PO program ends.

E2. *Management Plan*

Below is a graphical scheme of the management plan.